UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

BERKELEY, CALIFORNIA

THE DETERIORATION OF LUMBER

(A Preliminary Study)

BY

MERRITT B. PRATT

BULLETIN No. 252

Berkeley, Cal., May, 1915

UNIVERSITY OF CALIFORNIA PRESS

BERKELEY

1915

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THE DETERIORATION OF LUMBER

(A Preliminary Study)

By MERRITT B. PRATT

Lumbermen realize that lumber depreciates considerably from the time it leaves the saw until it is placed on board cars, but have little idea of the amount of injury and the possibilities of reducing the loss.

The present deterioration study followed the lumber from the time it left the sawmill until it was shipped. It determined as definitely as possible the loss in grade due to air-seasoning, kiln-drying, and finishing and the causes leading to the loss. The study was made in the yards of a representative lumber company in the northern part of the Sierra Nevada Mountains of California, and the results obtained are due, in large measure, to the co-operation of that company. The study was undertaken at the suggestion of, and in co-operation with, the United States Forest Service, through Mr. C. Stowell Smith, Assistant District Forester at San Francisco.

The data obtained concerns three species: sugar pine (*Pinus lambertiana* Dougl.); western yellow pine (*Pinus ponderosa* Laws.), which goes by the market name of California white pine; and Douglas fir (*Pseudotsuga taxifolia* Brit.), often called spruce in the market; these being the most valuable timber trees in the Sierras.

FACTORS AFFECTING DETERIORATION

AIR-DRYING

Among the important factors which affect the amount of depreciation in air-drying are the location of the yard, the method of piling the lumber, the climate and season of the year, and the dimension of the stock.

Yard.—The yard on the operation studied was poorly located for drying purposes. Its lower part was located on a black loamy soil which did not dry out readily and supported a heavy growth of grass and weeds, which retarded circulation of air in the piles. Good circulation of air was also prevented through the crowded condition and general location of the yard, it being only about ten acres in

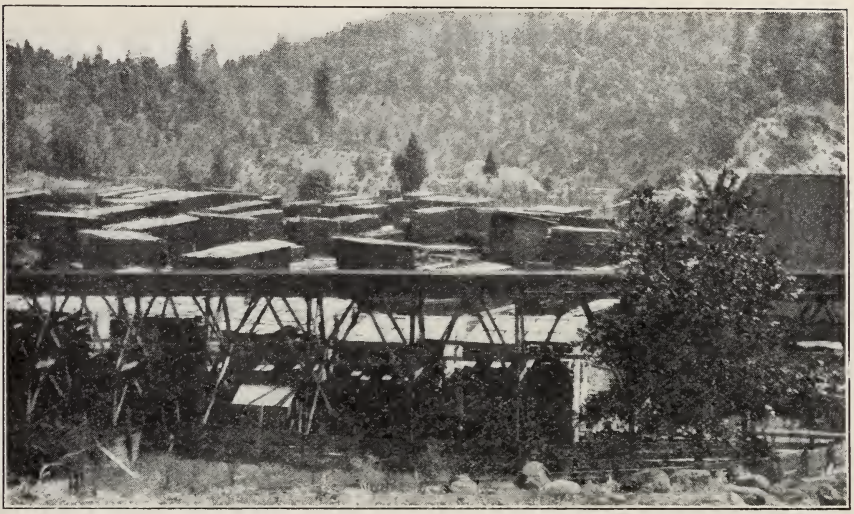

Fig. 1.—Yard in which the air-dried stock was tallied from the piles. Good circulation of air was hindered by surrounding mountains

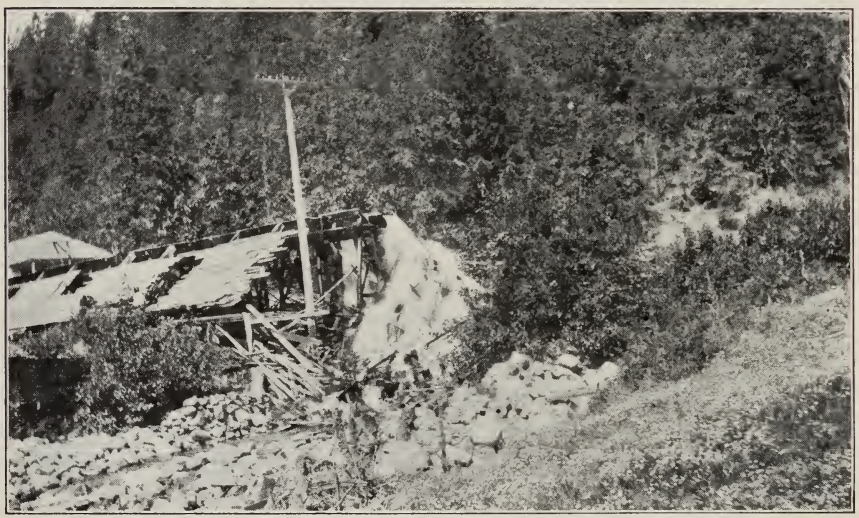

Fig. 2.—Terminus of flume carrying lumber from the sawmill four and a half miles distant

extent and closely hemmed in by surrounding mountains. The poor conditioning of the pine lumber in the piles in the lower part of the yard can be attributed mainly to poor air circulation. (See fig. 1.) The piles in the upper part, located on well-drained gravelly soil and

with free air circulation, dried out more quickly and with less deterioration in the grade of the lumber.

Piling.—Satisfactory conditioning of lumber depends in great measure on the way it is piled. The following principles are essential for good air-drying of sugar pine: (1) Foundation of pile should be solid and have good clearance above ground. (2) Piles should be open to provide for free circulation of air. (3) Stickers, or cross pieces, should be dry and regularly placed to hold the boards straight while they are seasoning. (4) Piles should slope and be well covered so that the water will run off quickly. (5) Piles should not be placed too closely together, since circulation of air will be hindered thereby. (See figs. 3 and 4.)

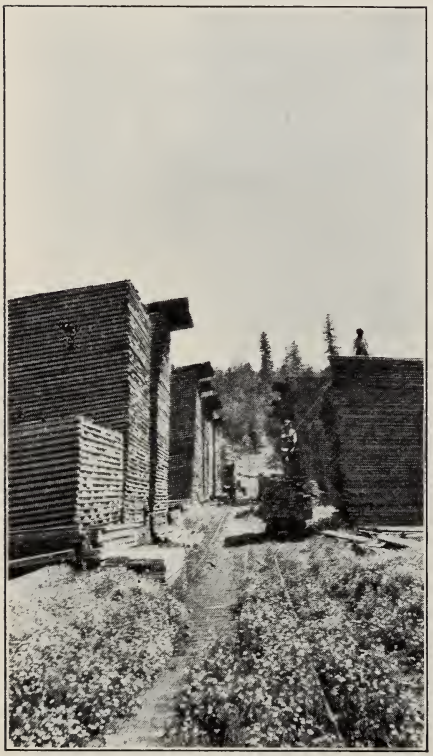

Fig. 3.—Piles of sugar pine lumber. Poor circulation conditions result from piles being too close together, also by reason of vegetation around the piles. View shows heavy growth of weeds, which tends to impede circulation of air in and around the piles.

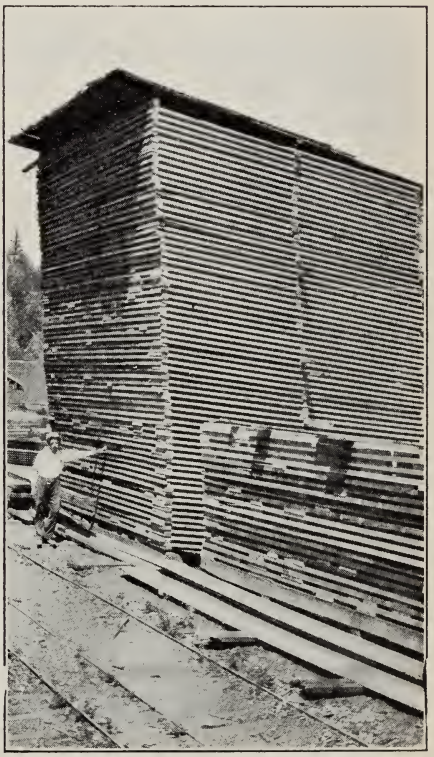

Fig. 4.—Better conditions for drying exist when piles are not shut in by other piles.

These principles were generally followed in the yard studied, except that the foundations in some instances were too low and did not provide for enough slope to the piles for the water to run off freely. This, coupled with the close piling in some places, caused much deterioration in grade on account of stain.

The typical pile was 20 feet high by 16 feet wide. The lumber averaged 16 feet long, 1½ inches thick, and 12 inches wide. The courses were separated by three $2 \times 4 \times 6$ inch Douglas fir stickers surfaced two sides. There were three chimneys 6 inches or more wide through the pile and an average spacing between the boards of 4 inches. The cover consisted of 1×12 Douglas fir boards projecting about 2½ feet at each end. The foundation was 18 inches from the ground in front and 12 inches in the back to give slope to the pile.

Climate and Season of the Year.—In the northern Sierras there is very little humidity in the air from June to October and a good breeze generally prevails during that period. In the spring and fall, on the other hand, there is more or less rainy weather and the circulation conditions are generally poor. Lumber is not sawed in this region in the winter. Lumber can often be well dried in from one to two months in the summer. During the spring and fall it not only requires a longer period to dry the lumber but there is greater depreciation during seasoning.

Dimension of Stock.—The thicker and wider the lumber the more liable it is to depreciation. The deterioration of 2-inch lumber was greater than for thinner stock, especially when there was heart on one side and sap on the other. Stock of this size should be sawed all sap or all heart if possible. It should also be cut early enough in the season to allow the stock to become dry before winter.

DEFECTS CAUSING DETERIORATION IN AIR-DRYING

To determine the loss in grade during air-drying, each board was tallied as it was taken down from the pile for shipment, the grader calling off the original grade as made at the mill when sawed, the present grade after air-drying, the contents in board feet, and the cause of deterioration in grade, if any. The following causes of deterioration were noted: blue stain, brown stain, check and warp, pitch, mechanical defects due to handling, and combinations of these that might change the original grade or footage.

Blue Stain.—Blue stain, which is very commonly found in pine lumber, is caused, as a rule, by a number of fungi, the activity of which produces discoloration in the sapwood, where there is an abundant food supply. The color is due in this case to the dark colored mycelium of the fungus, which is found as fine threads in the food-

containing wood rays and the parenchyma cells surrounding the resin cells. It is very likely, however, that some of the blue sap stain is not produced by fungi, but by chemical reactions, the discoloration often taking place very rapidly.

Blue stain is the most serious cause of depreciation in lumber with which lumbermen in northern California have to contend. It develops to a large extent in piles put up in the fall and which do not have time to dry out before the winter rains set in. It also develops where the drying conditions are poor, especially where free circulation of air is retarded by too close piling or by a growth of weeds beneath the pile. It is also brought about by unfavorable atmospheric conditions, such as a cloudy, humid period extending over several days with little or no breeze. Under such conditions lumber cut in the spring or fall blues very rapidly.

Log stain, which is a darker blue and more deeply embedded than the blue stain which develops in piled lumber, may be due to a chemical reaction. It develops very rapidly in logs cut and left in the woods, appearing first on the ends and gradually extending through the sapwood as the bark becomes loosened.

Lumbermen realize the advantages of open piling of pine in combatting blue stain and the necessity of free circulation of air. In many places the weeds are killed by sprinkling quicklime on the ground where the piles are to be placed. Since humid conditions and poor circulation promote blue stain, it is of advantage to have piles on soil with low moisture content and in positions where the air can circulate freely. When piles are shut in by surrounding piles the amount of stain is invariably greater than when the piles are free.

Blue stain does not injure the strength of the wood, since the walls of the wood cells are not destroyed by the fungus. It is the stained appearance of the lumber which seriously decreases its money value.

It is a problem to dispose of stained lumber. A grade of stained clear is made for finishing stock and second-class door cuttings are secured from No. 2 shop, which admits of slightly stained sap not extending over more than one-half of the face of the piece on one side. This must be the only defect, however, or the piece will be graded as box lumber. Some companies have a limited market for stained box shooks for cannery stock. Shippers of high class fruit, however, do not want a stained box, since it detracts from the appearance of the package. A common method of getting rid of stained lower grade lumber is to work it up into sheathing and car strips.

Brown Stain.—Brown stain, which is frequently not discernible in lumber until it has been finished, is a very serious defect. Its

presence is not due to fungi, but to a chemical reaction which takes place in green sap lumber upon exposure to the air. When the freshly cut surfaces are exposed to the air, under favorable conditions of temperature and moisture, a chemical reaction results which produces a colored substance on the wood. "Favorable conditions for sap-staining are found during warm weather and optimum conditions during extremely hot, humid summer weather, when lumber becomes discolored within a few hours. The examination of microscopic sections of this sap-stained lumber reveals the fact that the colored substance, produced by the chemical reaction, is most conspicuously developed in the wood rays and wood parenchyma cells, living tissues which are largely concerned in the storage and conduction of food in the wood."[1]

Professor John S. Burd, Agricultural Chemist, University of California, to whom samples of brown-stained sugar pine lumber were submitted, comments as follows:

"I submitted the samples to Professor R. E. Smith of the Division of Plant Pathology, who reports that he is unable to discover any organism in connection with the brown stain produced. This confirms my previous opinion, namely, that brown stain is probably due to oxidation of certain constituents of the wood, the exact character of which is unknown. Mr. Hibbard of this laboratory has treated samples of wood affected by the brown stain with a considerable number of oxidizing and reducing agents and has found it impossible to destroy the color so produced. I am therefore disposed to believe that after the stain has once occurred it will not be practicable to destroy same except by a process which would result in the destruction of the tissues of the wood. This means that in any attempt to mitigate the effects of brown stain it will be necessary to proceed along the lines of prevention rather than cure. In order to follow up such a method it would be necessary to make comparative experiments on timber under field conditions. Such experiments would require that the wood, seasoned by any method, should be checked by comparisons with tests of the same timber seasoned by the usual processes."

Both blue and brown stains are closely related to the food substances contained in the wood. Both of these agencies are dependent upon certain quantities of oxygen from the air, heat, and moisture. The conditions causing the worst sap staining, both blue and brown, are found in green sap lumber during hot, humid weather; whereas conditions tending to prevent staining are found in cool, dry weather and in logs immersed in water.

[1] Bailey, Botanical Gazette, Vol. 50, pp. 142–147. August, 1910.

Brown stain is not found in yellow pine. The presence of the sugary sap in sugar pine probably has something to do with the oxidizing process, resulting in brown stain, which is so common in lumber of that species. Brown stain is especially bad in lumber cut in early spring, when the tree is sappy. It is generally found as a distinct band between the heart and sap wood. Very frequently boards which have been subjected to especially unfavorable drying conditions have both blue and brown stains.

Sugar pine when put in the kiln is very subject to kiln-burn, which cannot be detected in surfaced lumber from the brown stain found in air-dried lumber. In fact, it is probable that it is brown stain caused through defective circulation conditions in the kiln the same as in the pile. (See fig. 5.)

Check and Warp.—No checking can occur until the surface of the wood has lost all its free water, that is, water in liquid form filling the pores. When the circulation of air is defective the transmission of water from the interior of the board to the surface does not go on uniformly, uneven drying takes place and case-hardening, followed by checking, results.

End checks are common on account of shrinkage caused by the ends of boards drying out more rapidly than the face. If a freshly cut board is exposed to the sun, the top surface dries out more rapidly than the lower surface, and on account of the uneven drying warping takes place. Uneven seasoning, therefore, results in checking and warping. Much check and warp can be avoided by putting sun covers on the piles during intervals of piling, especially on high grade stock, which does not accumulate very rapidly.

The harder the grain the greater is the liability to check and warp. This was evidenced in several cribs of kiln-dried cross-grained Douglas fir stock, a large proportion of which was checked and warped. Sugar pine does not suffer in grade from these causes nearly so much as yellow pine on account of its softer texture. Yellow pine and Douglas fir check and warp very badly when piled in the yard, consequently the upper grades are kiln-dried by the majority of lumber companies in this region.

Pitch.—Oftentimes pitch which is not discernible in the board on the grading tables at the mill appears in seasoning, both in the air-dried pile and in the kiln. It is a very common cause of misgrade at the sawmill. Pitch may occur in small pockets or in streaks, often resulting in the lowering of the grade. An Australian grade is made which admits of considerable pitch, but it is a serious defect in finishing stock used in this country.

Fig. 5.—Brown stain in sugar pine lumber

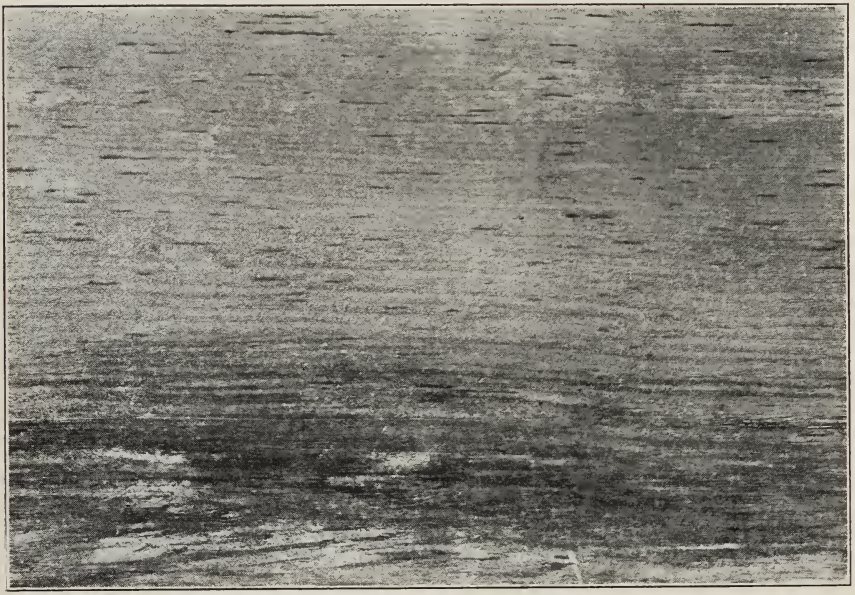

Fig. 6.—Kiln-burn in sugar pine lumber

Boards taken from the butt ends of trees which have been fire scarred are very pitchy as a rule. Pitch develops wherever the tree has been injured in any way. Pitch seams are found along lines of cleavage caused by wood shake or frost crack. On kiln-dried boards pitch globules are often found, the pitch having been forced out of the boards by the heat and coagulated on the outside.

Mechanical Defects Due to Handling.—On the operation studied injury from handling came about in three ways:

Handling of logs in woods in mill.—Sugar pine boards cut from the outside of a thin-barked log are often lowered in grade through too deep dogging in the woods. The turning of the logs in the mill with the steam niggers sometimes mars or breaks the board so that the grade is reduced.

Handling of lumber in flume.—The lumber was transported in a 30-inch V-shaped flume four and a half miles in length. (See fig. 2.) The upper grades are often broken or split by the impact of heavy timbers. Jams sometimes result, the boards being thrown out on the rocks below. Heavy sugar pine boards, known as "sinkers," become waterlogged and sink, and the handling they receive from the iron hooks of the men on the flume often materially reduces the grade. The wider the boards the greater is the danger of injury in the flume. In fact, the damage is so great that wide boards are not cut when the water is low.

Handling in yards.—A very common source of injury comes about in the dumping of the lumber from the flume to the skid through breakage or splitting of the ends of the boards. The lumber is handled several times after it leaves the skids and before it is placed on board cars. Breakage begun in the flume is apt to become intensified every time the lumber is handled. The piling jacks used in getting boards to the tops of piles dig holes into boards unless carefully handled. The loss from handling in the yard, however, is a small item compared with the loss in fluming. (See fig. 7.)

KILN-DRYING

The artificial seasoning of the upper grades of lumber in dry-kilns is being resorted to more and more by lumbermen, now that methods have been perfected whereby nearly all kinds of lumber can be seasoned with a small percentage of loss.

There are three conditions which must be carefully looked after if lumber is to be kiln-dried successfully. These are heat, air circulation, and humidity. If each of these factors can be properly controlled the lumber can be successfully dried. To avoid split, warp, and check it is essential that a definite relation be maintained between

the evaporation from the surface and the transmission of moisture within the board. This condition can be obtained by observing the following principles:

(1) The temperature of the lumber must be maintained uniformly throughout the entire pile.

(2) A large and continuous circulation of air must be maintained.

(3) Control of the drying process at any given temperature must be secured by controlling the relative humidity, not by decreasing the air circulation. This may be accomplished either by suitable ventilation or by having steam jets in the kiln.[2]

The kiln used in the operation studied is an old type, operated by the steam heat blower system, live steam being carried to the steam coils from the boiler. The heated air is forced through ventilators in the front of the kiln, up through the lumber to the top and down the side walls to the air drum, which carries it again to the steam coils. A continuous circulation of air is kept up by a fan situated in front of the steam coils. Lumber is gradually moved to the discharging end of the kiln, the moisture being taken up by the heated air until the lumber reaches the degree of dryness desired.

Temperature, humidity, and air circulation were exceptionally well regulated in the kiln studied, but the loss, although less than in air-drying, is a considerable item. The loss in grade was chiefly due to check, split, and warp in yellow pine and Douglas fir and kiln-burn and check in sugar pine.

The checking and splitting took place generally in hard, cross-grained pieces. It also was found in cribs of lumber where the proper relations had not been maintained between the evaporation from the surface and the transmission of moisture within the board.

Kiln-burn in sugar pine usually causes such a large amount of deterioration that many operators do not attempt to kiln-dry it, except when it must otherwise be left to dry in the yards over winter. In this case the upper grades are put in the kiln with the idea that the lumber could not possibly be spoiled to a greater degree than if left green in the yard.

The system of kiln-drying sugar pine has usually been that of keeping a low, steady temperature during the entire drying period. The experiment was made in the kiln studied of subjecting sugar pine to the same heat as yellow pine, starting with 130° and gradually raising it to 180° before the lumber was removed from the kiln. The kiln-burn was much less with this method than under the low heat system. Much investigation, however, is needed before this matter can be definitely settled. (See fig. 6.)

[2] Tiemann, Principles of Drying Lumber at Atmospheric Pressure, Bulletin 104, Forest Service, U. S. Dept. of Agr., p. 6.

Fig. 7.—Lumber on skids as dumped from the flume

Fig. 8.—Crib of kiln-dried yellow pine ready to be regraded. Lateral chimneys shown

SURFACING

The grade of lumber as taken down from the pile or from the kiln does not always hold after it has been surfaced. Planing may improve the grade by removing the defects which kept the grade down in the rough, but it generally brings to light defects such as brown stain or check that were not before discernible, thereby causing the grade to fall.

In order to secure this factor of reduction, a quantity of lumber that had already been tallied from the kiln or from the yard was tallied through the planer, the complete history being obtained from the time the lumber left the mill until it was put on board cars.

DATA SECURED IN THE PRESENT STUDY

The following are the average prices received for the different grades of lumber in this vicinity at the time the study was made and upon which the monetary loss as given is based:

PINE

Grade	Selling price per 1000 bd. ft.
No. 1 and No. 2 clear sugar pine	$54.00
No. 1 and No. 2 clear yellow pine	40.00
No. 3 clear sugar pine	42.00
No. 3 clear yellow pine	35.00
No. 1 shop sugar pine	29.00
No. 1 shop yellow pine	26.00
No. 2 shop sugar pine	20.00
No. 2 shop yellow pine	17.50
Australian	34.50
Stain clear	30.00
Box	15.00

DOUGLAS FIR

Grade	Selling price per 1000 bd. ft.
Clear	$27.50
Select	22.50
No. 1 and No. 2 dimension	16.50
No. 3 dimension	12.00

AIR-DRIED LUMBER

Sugar pine lumber was tallied from piles which had been put up in the fall, spring, and summer, since it is evident that drying conditions vary considerably with the season irrespective of the way the pile is put up. The percentage of loss varied greatly, the greatest depreciation in grade being found in the fall-piled lumber and the

least in the summer-piled stock. Blue stain was especially bad in fall piles. The following tables show the amount of depreciation under various conditions.

FALL-PILED SUGAR PINE

Total amount tallied, 41,812 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber deteriorating in grade, per cent	Chief cause of deterioration and proportion of all lumber in pile affected by it	Loss per 1000 bd. ft. from all causes, dollars
1 and 2 clear*	6/4	75.5	Blue stain, 52%	17.90
3 clear	6/4	71.2	Blue stain and check, 54%	11.27
1 shop	5/4	70.6	Blue stain and check, 36%	8.87
1 shop	4/4	68.0	Blue and brown stains, 62%	9.96

* Field data on one pile 1 and 2 clear taken by Swift Berry, Forest Examiner, U. S. Forest Service.

SPRING-PILED SUGAR PINE

Total amount tallied, 51,147 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber deteriorating in grade, per cent	Chief cause of deterioration and proportion of all lumber in pile affected by it	Loss per 1000 bd. ft. from all causes, dollars
1 shop	6/4	41	Blue stain and check, 21%	4.23
1 shop	8/4	56	Blue stain and check, 43%	6.35
2 shop	6/4	21	Blue stain and check, 15%	1.11
2 shop	8/4	36	Blue stain and check, 24%	1.82

SUMMER-PILED SUGAR PINE

Total amount tallied, 225,156 bd. ft.*

Original grade	Thickness of lumber, inches	Proportion of lumber deteriorating in grade, per cent	Chief cause of deterioration and proportion of all lumber in pile affected by it	Loss per 1000 bd. ft. from all causes, dollars
1 and 2 clear	4/4	11.6	Blue stain and handling, 8.7%	3.03
3 clear				2.31
Australian				1.94
1 shop				1.32
1 and 2 clear	5/4	11	Blue stain and handling, 6%	3.18
3 clear				1.74
Australian				1.63
1 shop				.57
1 and 2 clear	6/4	13.2	Check, 2.8% Handling, 4.2% Blue stain, 2.6% Brown stain, 2%	2.95
3 clear				3.42
1 shop				1.02
1 and 2 clear	8/4	29.7	Check, 11.7% Blue stain, 8.4% Handling, 4%	7.47
3 clear				6.66
Australian				2.42
1 shop				1.03
2 shop				.62

* This lumber was tallied by S. B. Show, Forest Examiner, and E. B. Long, Forest Ranger, both of the U. S. Forest Service.

The lumber which was found to have held its grade in the No. 2 shop piles in the spring-piled sugar pine, amounting to 19,838 board feet, was then surfaced on two sides for shipment and again graded after surfacing. Some of the defects surfaced out, while others, particularly brown stain, appeared. There was a gain of 47 cents per thousand board feet in the lot from one pile of No. 2 shop and a loss of 31 cents per thousand board feet in the other pile through surfacing.

Mr. Show also tallied 5310 board feet of No. 3 clear sugar pine, which was surfaced two sides directly after it had been taken down from a pile of summer-dried stock. It was found that there was a loss of $1.44 per thousand board feet due to blue and brown stains which did not show up in the rough.

KILN-DRIED LUMBER

Sugar Pine.—It has not been the practice of the lumber company in whose yards this study was made to kiln-dry sugar pine because of the loss to which it was thought it would be subject from kiln-burn. An experimental run of 14,000 board feet of No. 1 and No. 2 shop was made, however, to compare the loss in grade with summer air-dried stock. The following comparatively small loss was the surprising result:

Total amount tallied, 14,000 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber showing deterioration per cent	Chief cause of deterioration	Loss per 1000 bd. ft. from all causes, dollars
1 shop	6/4	8	Check and kiln-burn	1.82
1 shop	8/4	12	Check and kiln-burn	1.90
2 shop	6/4	2	Check and kiln-burn	.11
2 shop	8/4	5	Check and kiln-burn	.27

The lumber which held its grade, amounting to 9028 board feet, was then surfaced and again graded. Additional check and kiln-burn appeared, causing a further depreciation of 26 cents per thousand board feet for No. 1 shop and 5 cents per thousand board feet for No. 2 shop.

Western Yellow Pine.—The lumber was piled wide apart so that every board would be exposed to the warm air and evaporation of moisture would take place readily. There was an average of twenty-eight courses of 1½-inch lumber to the car, with three lateral 4-inch chimneys made by placing 2×4 inch stickers at the bottom of the

twelfth, eighteenth, and twenty-fourth courses from the top. The average length of drying was ten days. (See fig. 8.)

Total amount tallied, 80,000 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber showing deterioration per cent	Chief cause of deterioration	Loss per 1000 bd. ft. from all causes, dollars
1 and 2 clear	4/4	5	Check	.70
1 and 2 clear	5/4	14	Check	1.25
1 and 2 clear	6/4	6	Check	.71
1 and 2 clear	8/4	23	Check	3.41
3 clear	6/4	6	Check	.64
3 clear	8/4	23	Check	3.46
Australian	8/4	23	Check	2.42
1 shop	4/4	5	Check	.85
1 shop	6/4	6	Check	.64
1 shop	8/4	23	Check	2.31
2 shop	8/4	23	Check	.65

A further depreciation was found to take place in yellow pine lumber which was surfaced after being taken directly from the kiln, as shown in the following table:

Total amount tallied, 12.709 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber showing deterioration, per cent	Chief cause of deterioration	Loss per 1000 bd. ft. from all causes, dollars
3 clear	8/4	6	Check	.72
1 shop	8/4	4	Check	.70
2 shop	6/4	2	Check	.11

Douglas Fir.—The lumber was piled very closely to keep it from drying out too quickly. There was an average of thirty-four courses of inch lumber to the car, with two lateral 4-inch chimneys made by placing 2×4 inch stickers at the bottom of the eighteenth and twenty-eighth courses from the top. Douglas fir lumber in this vicinity is of very hard texture and warps and checks badly if not carefully treated in the kiln. Even then cross-grained stock warps and splits because of its extreme hardness. The few pieces of 2-inch lumber put in with the inch stock showed a large proportion of check. The average length of drying was five days.

Total amount tallied, 53,000 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber showing deterioration, per cent	Chief cause of deterioration	Loss per 1000 bd. ft. from all causes, dollars
Clear	4/4	9	Check and warp	.73
Clear	8/4	16	Check and warp	2.91
Clear	4/4	9	Check and warp	.32

SURFACED LUMBER

In addition to the surfaced lumber amounting to 19,838 board feet of spring-piled air-dried sugar pine, 5310 board feet of summer-piled air-dried sugar pine, 9028 board feet of kiln-dried sugar pine, and 12,709 board feet of kiln-dried yellow pine, which was again graded directly after it had been taken from the pile and kiln and the results of which have already been stated, the following data were taken regarding change in grade due to surfacing of lumber which had been stored in sheds.

Sugar Pine, Surfaced Two Sides.—The lumber in the following table had been graded down from the piles the year before and stored in the sheds until needed. The brown stain shown in surfacing either was not detected by the grader in the rough or developed in storage, since this proportion of deterioration was not found in lumber taken directly from the piles to the planer.

Total amount tallied, 38,000 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber deteriorating in grade, per cent	Chief cause of deterioration and proportion of all surface lumber affected by it	Loss per 1000 bd. ft. from all causes, dollars
1 shop	5/4	54	Brown stain, 32%	7.43
1 shop	8/4	45	Brown stain, 24%	5.45
2 shop	6/4	31	Brown stain, 21%	1.54

Considerable trouble is experienced in shipping sugar pine because of brown stain. Cases have been known where there was apparently no brown stain in the lumber at the time it was shipped, but which was found by the consignee when the car reached him. One company lost a hundred dollars on a car of high grade stock through brown stain, which was not apparent at the time of shipping. The probabilities are that the lumber was not thoroughly dry when it was shipped. The many complaints along this line are leading lumbermen dealing in sugar pine to use the utmost care in its seasoning.

Western Yellow Pine, Surfaced Two Sides.—As a basis of comparison with the loss sustained by sugar pine taken from the sheds, kiln-dried yellow pine which had also been stored was followed through the planer and tallied when loaded on board cars. The absence of brown stain made the loss per thousand board feet much lower than for sugar pine, but it was greater than for lumber surfaced after being taken directly from the kiln. A greater amount of check was apparent, which may have been due to storage conditions.

Total amount tallied, 29,103 bd. ft.

Original grade	Thickness of lumber, inches	Proportion of lumber deteriorating per cent	Chief cause of deterioration	Loss per 1000 bd. ft. from all causes, dollars
1 and 2 clear	4/4	5	Check	1.63
1 and 2 clear	6/4	10	Check	3.22
1 and 2 clear	8/4	3	Check	1.97

SUMMARY

The data gathered in this preliminary study are not sufficient in amount, range of conditions, or length of time to warrant a statement of final conclusions either as regards the amount of the loss or the best means of reducing that loss. The object of this report is to call attention to the fact that this is a problem worthy of careful study and to make available at once such data as are now at hand. The United States Forest Service is conducting much more extensive investigations along the same line over a wide range of conditions.

The present figures show that the loss due to depreciation in the grade of the lumber from the time it leaves the saw until it is shipped is far greater than was generally imagined. This is especially true for sugar pine, which is considered the most valuable species in the Sierras and for which the highest stumpage rate is asked by the United States Forest Service. Sugar pine lumber appears to be extremely susceptible to depreciation, particularly to blue stain and brown stain. On account of the rate at which it deteriorates in this locality, the company in whose yards data concerning it were taken contends that it is making more profit on its western yellow pine (known to the trade as California white pine), the upper grades of which can be kiln-dried without an undue amount of loss. If sugar pine could be kiln-dried successfully, and it is believed that this will be done in a short time, the present large loss through air-seasoning would be greatly decreased.

The following conclusions regarding the deterioration of the upper grades of sugar pine, western yellow pine, and Douglas fir from the time the lumber leaves the sawmill until it is ready for shipment are indicated by the limited amount of data thus far available.

SUGAR PINE

1. The upper grades of sugar pine deteriorated much more in seasoning than did western yellow pine or Douglas fir. Of the sugar pine lumber of the upper grades, the percentage which deteriorated in grade during air-seasoning was approximately 71 per cent, 38 per cent, and 16 per cent for the fall, spring, and summer drying, respectively. When surfaced there was a further deterioration due to brown stain; this was greater in the lumber taken from the storage sheds than in that taken direct from the piles.

2. The average loss for all lumber tallied in unfinished upper grades of sugar pine through fall seasoning was approximately $12 per thousand board feet as compared with an average loss of $2.58 per thousand board feet through summer seasoning.[3] The average loss through spring seasoning cannot be given in comparable terms, inasmuch as no spring seasoned lumber above No. 1 shop was tallied. From the loss in No. 1 shop, however, it is estimated that the average loss in spring seasoning for all the upper grades was about $5 per thousand board feet.

3. One experiment in kiln-drying sugar pine at the same temperature as western yellow pine and Douglas fir indicated that the deterioration in the upper grades of sugar pine lumber would be much less if kiln-dried than when air-dried in the spring or fall. Ninety-three per cent of the small amount of No. 1 and No. 2 shop lumber which was run through the kiln retained its original grade, and there was an average loss of only $1 per thousand board feet for all the lumber in this lot. The depreciation in surfacing caused an additional loss of 26 cents per thousand board feet for No. 1 shop and 5 cents per thousand for No. 2 shop. This total loss is about the same as that of air-dried summer-piled lumber of these grades. Until the matter of kiln-drying sugar pine has been worked out more satisfactorily, however, it seems preferable to air-dry the summer-cut stock.

4. Blue stain and brown stain, the greatest sources of depreciation in sugar pine lumber, are largely the result of poor drying conditions.

[3] The average is computed for all lumber, including that which did not deteriorate at all. The relative amounts and thickness of each grade were not considered in making the averages, which are only approximate. For losses by grades see tables given previously.

i.e., imperfect circulation of air, poorly drained soil, failure of the pile to shed rainwater, or damp, rainy weather. It is necessary that the air should circulate above, below, and around each board. Less stain developed in piles in the open than in those shut in and less in piles which were located on well drained areas than when on soils retentive of moisture. Stain developed to a great extent in piles put up in the fall when humid atmospheric conditions prevailed. Some piles put up in the spring showed stain more than others, depending on their location. In summer, when dry, breezy conditions prevailed, the lumber did not depreciate any more from stain than from other agencies, such as check and handling.

5. Although the heavy loss of grade in air-seasoned sugar pine is due in part to poor yards and handling, yet under any conditions of seasoning a large loss is liable to occur, due to the sensitiveness of the wood to blue stain and brown stain. This characteristic of the lumber should be considered in fixing stumpage rates; the value should be fixed in accordance with the ultimate grade and value of the species rather than its grade and value at the saw. The present data lead to the conclusion that the proper relationship does not now exist in the vicinity studied between the stumpage price paid for sugar pine and for western yellow pine.

WESTERN YELLOW PINE (CALIFORNIA WHITE PINE)

Experience has proved that air-dried western yellow pine lumber checks so badly in this vicinity that it pays to kiln-dry all of the upper grades. Approximately 80 per cent of the western yellow pine tallied in this study retained the original grade as made at the mill after the lumber had been kiln-dried and surfaced. The average loss through deterioration during kiln-drying of the upper grades was approximately $1.55 per thousand board feet. When the lumber was surfaced on two sides there was a further loss ranging from 51 cents per thousand board feet in lumber taken directly from the kiln to $2.27 per thousand board feet in that stored in the sheds. More checking occurs in western yellow pine when the kiln is crowded or the lumber piled close together than when there is ample room for circulation. The thicker the lumber the greater is the deterioration due to check.

DOUGLAS FIR

The upper grades of Douglas fir are very successfully kiln-dried. Experience has shown that in this locality it does not pay to air-dry the upper grades of this species and that kiln-drying is the only practicable method of getting it through with anything like its original grade. Approximately 91 per cent of the upper grades of Douglas fir one inch in thickness retained the original grade when shipped after being kiln-dried. The average loss through deterioration due to kiln-drying was 53 cents per thousand board feet for 1-inch lumber and $2.90 per thousand board feet for 2-inch lumber, which checks very badly.

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